REMARKS

Independent claims 30 and 31 have been amended to recite that the ratio of the area of the negative to the area of the positive electrode is set such that the element resistance measured between the negative and positive electrodes is minimized. Claims 16 and 32-34 have been amended to recite that the respective areas are set such that the element resistance is minimized. Support is found, for example, by reference to Fig. 6 and the disclosure bridging pages 15-16 of the specification.

Review and reconsideration on the merits are requested.

Claims 32-34 were rejected under 35 U.S.C. § 112, second paragraph. The Examiner did not consider these claims as further limiting the subject matter of other claims presented for examination, further noting that expressions of intended use (e.g., for determining oxygen concentration) are not structural limitations.

Applicants respond as follows.

The pending claims are claims 16-20, 22-24 and 30-35.

Claims 32-34 define an oxygen sensor, a humidity sensor and a second type of oxygen sensor for determining the oxygen concentration as a component of a gas containing NOx. Each defines the claimed sensor as comprising first and second chambers formed between first and second oxygen-ion conductive cell substrates among other structural features. These differ from claims 16-20 and 22-24 which do not define a sensor having first and second chambers. Claims 32-34 similarly differ from claims 30 and 31.

Therefore, it seems that the rejection is incorrect, and withdrawal is respectfully requested.

Claims 30-35 were rejected under 35 U.S.C. § 102(a) as being anticipated by U.S. Patent 5,672,811 to Kato et al. Claim 31 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Kato '811. Claim 33 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Kato '811 in view of U.S. Patent 5,348,630 to Yagi et al. Finally, claims 16-20 and 22-24 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Kato '811 in view of JP 5-87773 or U.S. Patent 4,657,659 to Mase et al.

The Examiner cited Fig. 2 of Kato '811 as disclosing a sensor including chambers 6 and 8, electrodes 28 and 24 supported on the same side of substrate 4c, and means 30 for applying a voltage of 450 mV or 1.5 volts between the electrodes. Based on the drawings, electrode 28 (negative electrode) is said to have an area at least twofold that of electrode 24. Figs. 11-15 were cited as showing electrodes 28 and 24 disposed on the same side of an electrolyte. Yagi et al was cited as disclosing the use of a zirconium solid electrolyte sensor for measuring humidity. JP '773 and Mase et al recited as disclosing embedded electrodes.

Applicants respectfully traverse for the following reasons.

The present invention is based on Applicants' discovery that the electric resistance between electrodes disposed co-planar on the same side of a solid electrolyte substrate constituting a detection cell can be minimized by appropriately specifying the electrode-area relationship between the positive and negative electrodes. As a result, the S/N ratio is improved. This is particularly important because the detection current in such a sensor having a co-planar electrode arrangement can be rather small.

This phenomenon is shown in Fig. 6, where the element resistance is minimized within an area ratio of the negative and positive electrodes ranging from 2:1 to 5:1 or from 1:2 to 1:5. When the negative and positive electrodes have the same area (i.e., a ratio of 1:1), the element resistance is remarkably increased. Likewise, the element resistance is likewise increased at an area ratio exceeding 5:1 or 1:5.

Each of amended claims 16, 30, 31, 32, 33 and 34 requires a ratio of the area of the negative electrode to the area of the positive electrode set within a specified range such that the element resistance measured between the negative and positive electrodes is minimized. The Examiner did not address this requirement (of claim 16) in the Office Action dated March 12, 2002. Furthermore, there is nothing in Kato '811 (or the other prior art references applied by the Examiner) which fairly teaches or suggest the desirability of setting the ratio of the electrode areas so as to minimize the element resistance.

That is, the claims as amended not only require setting the ratio of the areas within a specified range (e.g., at least twofold, or within the range of 2:1 to 5:1 or within a range of 1:2 to 1:5), but also, setting the ratio of the area of the negative electrode to the area of the positive electrode such that the element resistance is minimized. Although Kato '811 would appear to show electrodes supported on the same side of the substrate having areas which differ by at least twofold, Kato '811 is silent with respect to the area ratios of these electrodes or the significance thereof.

Furthermore, although Kato '811 may show a negative electrode having an area larger than that of a positive electrode, Kato '811 does not show a state where the element resistance is

minimized, and further, does not recognize that the element resistance will further increase as the area ratio is increased.

Minimization of the resistance between the positive electrodes formed on the same electrolyte layer is important. Otherwise, stable measurement is not obtained when the current between the electrodes is very small. Nothing in the prior art discloses this aspect of the invention.

Withdrawal of all rejections and allowance of claims 16-20, 22-24 and 30-35 is earnestly solicited.

In the event that the Examiner believes that it may be helpful to advance the prosecution of this application, the Examiner is invited to contact the undersigned at the local Washington, D.C. telephone number indicated below.

Respectfully submitted,

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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

The claims are amended as follows:

All below from Am 116 10/19/01

16. (Twice amended) A sensor element comprising negative and positive electrodes disposed on the same side of a solid electrolyte substrate and a circuit for applying an electric potential between said negative electrode and said positive electrode, wherein

the area of said negative electrode and the area of said positive electrode differ by at least twofold and [is] said areas are set such that the element resistance measured between the negative and positive electrodes is minimized,

at least one of said negative electrode and said positive electrode is embedded in the solid electrolyte substrate; and

the area ratio of the negative and positive electrodes is such that the element resistance measured between the negative and positive electrodes is 94% or less than the element resistance of the same sensor except in which the negative electrode and the positive electrode have the same area.

30. (Twice amended) A sensor for detecting an amount of a gas, comprising

an oxygen-ion conductive solid electrolyte substrate having a flat side, a negative electrode and a positive electrode formed on the same flat side of the substrate so as to pump

oxygen from the negative electrode to the positive electrode, and a gas diffusion limiting means for limiting the gas diffusing into the negative electrode,

wherein the ratio of the area of said negative electrode to the area of said positive electrode is set within a range of 2:1 to 5:1 such that the element resistance measured between the negative and positive electrodes is minimized, and

said sensor comprising a circuit for applying an electric potential between said negative and positive electrodes such that a pump current of less than 100 microamperes flows between the negative and positive electrodes when the sensor is used for detecting the amount of a gas, said pump current being a measurement of the amount of gas.

31. (Twice amended) A sensor for detecting an amount of a gas, comprising

an oxygen-ion conductive solid electrolyte substrate having a flat side, a negative electrode and a positive electrode formed on the same flat side of the substrate so as to pump oxygen from the negative electrode to the positive electrode, and a gas diffusion limiting means for limiting the gas diffusing into the negative electrode,

wherein the ratio of the area of said negative electrode to the area of said positive electrode is set within a range of 1:2 to 1:5 such that the element resistance measured between the negative and positive electrodes is minimized, and

said sensor comprising a circuit for applying an electric potential between said negative and positive electrodes such that a pump current of less than 100 microamperes flows between the negative and positive electrodes when the sensor is used to detect the amount of a gas, said pump current being a measurement of the amount of gas.

32. (Amended) An oxygen sensor for determining the oxygen concentration of a gas, comprising first and second chambers (62, 64) formed between first and second oxygen ion conductive cell substrates (66, 68) and first and second electrodes (68a, 68b) formed on the same plane of the second cell substrate (68), said first electrode (68a) being formed on an inside wall of the second chamber (64) and said second electrode (68b) being formed outside of the second chamber (64),

wherein the area of the first electrode is at least twofold larger than that of the second electrode and said areas are set such that the element resistance measured between the negative and positive electrodes is minimized, and

the second comprises a circuit for applying an electric potential in the range of 0.2 V to 1.1 V between the first and second electrodes such that a pump current of less than 100 microamperes flows between the first and second electrodes when the sensor is used to determine the concentration of oxygen in a gas, said pump current being a measurement of oxygen concentration.

33. (Amended) A humidity sensor for determining the humidity of a gas, comprising first and second chambers (62, 64) formed between first and second oxygen ion conductive cell substrates (66, 68) and first and second electrodes (68a, 68b) formed on the same plane of the second cell substrate (68), said first electrode (68a) being formed on an inside wall of the second chamber (64) and said second electrode (68b) being formed outside of the second chamber (64),

wherein the area of the first electrode is at least twofold larger than that of the second electrode and said areas are set such that the element resistance measured between the negative and positive electrodes is minimized, and

the sensor comprises a circuit for applying an electric potential in the range of 1.1 V to 2.5 V between the second electrodes such that a pump current of less than 10 microamperes flows between the first and second electrodes when the sensor is used to determine the humidity of a gas, said pump current being a measurement of humidity.

34. (Amended) An oxygen sensor for determining the oxygen concentration as a component of a gas containing NOx, comprising first and second chambers (62, 64) formed between first and second oxygen ion cell substrates (66, 68) and first and second electrodes (68a, 68b) formed on the same plane of the second cell substrate (68), said first electrode (68a) being formed on an inside wall of the second chamber (64) and said second electrode (68b) being outside of the second chamber (64),

wherein the area of the first electrode is at least twofold larger than that of the second electrode and said areas are set such that the element resistance measured between the negative and positive electrodes is minimized, and

the sensor comprises a circuit for applying an electric potential in the range of 0.2 V to less than 0.5 V such that a pump current of less than 100 microamperes flows between the first and second electrodes when the sensor is used to determine oxygen concentration as a component of a gas containing NOx, said pump current being a measurement of oxygen concentration.